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A SURVEY OF THE SANDY RIVER AND ITS TRIBUTARIES, 1940, WITH REFERENCE TO FISH MANAGEMENT

By

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and

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Washington
1940

This is the fourteenth in a series of mimeographed Special Scientific Reports, published in limited quantities for the official use of Federal offices and cooperating agencies. The reports present the results of investigations of specific problems and are intended as guides for administrative and legislative action. In many instances the data will be incorporated in complete scientific publications that will be printed and released at a future date. Previous reports in this series are as follows:

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10. An investigation of fish-salvage problems in relation to Shasta Dam, by H. A. Hanson, O. R. Smith, and P. R. Needham.

11. Pollution survey of the Cumberland River in the vicinity of Nashville, Tenn., August 1936, by M. M. Ellis and B. A. Westfall.

12. Mine-waste pollution of Bear Butte Creek, Black Hills, South Dakota, by M. M. Ellis.

13. Industrial and organic pollution of the Buffalo River, Buffalo, New York, by B. A. Westfall.

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A SURVEY OF THE SANDY RIVER AND ITS TRIBUTARIES, 1940, WITH REFERENCE TO FISH MANAGEMENT[1/]

By

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and

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INTRODUCTION

Because of its close proximity to Portland, Oreg., and the fact that it is one of the few large tributaries of the Columbia River entering below Bonneville Dam and fairly near to that structure, the Sandy River has been the subject of considerable interest and discussion in regard to the possibilities of developing it for sport fishing and improving and rehabilitating its salmon runs, which are reported to have been large at one time. With these purposes in mind requests have been made of the Federal Government to appropriate funds to be used to make permanent the diversion dam and construction work done by the Oregon Game Commission which diverts the flow of the Sandy River through the Little Sandy channel giving a satisfactory, deep entrance to the stream from the Columbia River. Previous to that construction the water in the main Sandy River channel often became so shallow that fish could not easily enter the stream. Also, requests have been made for the construction of a salmon hatchery on this stream.

In order to determine the present status of the Sandy River in regard to fish life and to secure facts which would serve as a basis for deciding whether or not the above program of development is practical and warranted, it was necessary to make a survey of the river system. The survey[2/] was conducted by the same methods being used in the program of investigation by which the entire Columbia River watershed will be surveyed. However, because of the need for haste, the entire Sandy River

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1/ Submitted August 6, 1940.

2/ Survey made by M. G. Hanavan, Junior Aquatic Biologist, and Z. E. Parkhurst, Junior Aquatic Biologist.

system was not covered by this survey in detail in the routine manner.

The Sandy River rises on the western slope of Mount Hood and flows approximately 45 miles in a northwesterly direction to empty into the Columbia River about 18 miles east of Portland, Oreg. It has three major tributaries, the Zigzag, Salmon, and Bull Run Rivers. The Zigzag and Salmon Rivers rise in glaciers near Mt. Hood while the Bull Run River has its source in high mountain lakes. Together with several minor tributaries these rivers form a system that at one time was an important salmon producer.

Any plan for the rehabilitation of this river system as a salmon stream becomes at once involved in the consideration of the effect of the several dams and diversions that have been constructed in the Sandy River and its tributaries. These structures form a rather complicated system of hazards to fish life, so it is well to mention them at once in respect to location and purpose, and present a more detailed account of them later in the report. The Portland General Electric Company has a dam across the main Sandy River at Marmot, 27 miles above the confluence of the Sandy River with the Columbia River. This dam diverts water from the Sandy River into a flume and tunnel which empties into the Little Sandy River immediately above another dam, also owned by the Portland General Electric Company. The flow of the Little Sandy River, and the water brought in by the Marmot diversion, is then diverted into another flume which carries it into a reservoir from which it discharges through a power house into the Bull Run River about 1½ miles above the forks of the Bull Run and main Sandy Rivers.

In addition to this power project of the Portland General Electric Company, the City of Portland has used the Bull Run River as a source of municipal water supply for many years. They maintain a diversion dam across the Bull Run about 3 miles above the point where that stream unites with the Little Sandy River. A pipe line carries the water from the diversion dam to the City of Portland. Five miles upstream a storage dam is located. A more detailed description of these structures now follows. Reference to the map which accompanies this report (fig. 1) will assist in clarifying the explanations.

MARMOT DAM

Marmot Dam is located on the Sandy River, 27 miles upstream from its confluence with the Columbia River. This dam, owned and maintained by the Portland General Electric Company, is the only power diversion dam on the main river. It is constructed of concrete, with plank facing on the spillway and is provided with a timber-crib downstream apron. The dam has a crest length of approximately 400 feet, and is 30 feet high; this height being the distance from the water level below the dam to the crest of the spillway. At the time of the survey, on March 19, 1940, there was a spill of water 3 to 8 inches deep pouring over the dam. Six-inch flash boards were set in place on the full length of the crest.

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The dam is provided with a fish ladder (fig. 2) located at its south end which is constructed of concrete. There are 35 steps in the ladder with varying heights of from 8 to 12 inches, and a water depth in the intervening pools of 24 inches, with 19 inches of the sides of the ladder above the water level. These pools are 6 feet wide and 8 feet long. A removable trap for catching steelhead trout is operated at the upper end of the fish ladder by the Oregon Fish Commission in connection with their hatchery located below the dam. At the present time this ladder is able to accommodate successfully the small run of chinook and silver salmon reaching the dam.

Water is diverted from the north end of the dam into the diversion canal through two drum-type headgates approximately 10 feet wide. Irregularly spaced trash bars and a shear boom are located in front of the headgates for the purpose of stopping floating debris. The depth of water at the intake at the time of the survey was about 8 feet. The canal is 20 feet wide with a depth of water of 5 to 6 feet on the day of the survey and was flowing about 500 to 600 c.f.s. At that time the flow of the Sandy River 1½ miles above the dam was 1,300 to 1,400 c.f.s. This diversion is not provided with any screens or other protection to prevent fish from entering it from the river. During the months of July, August, and September, the volume of water carried by the Sandy River is so reduced that all of its flow, except the small amount going down the fish ladder, is taken out by the diversion canal. This diversion enters the Little Sandy River just above the Little Sandy Dam.

LITTLE SANDY DAM

The diversion dam on the Little Sandy River (fig. 3) is located 2 miles above the entrance of this stream into the Bull Run River. This is a concrete structure with a crest length of 92 feet and a height of 15 feet, the distance from the river bed below the dam to the crest of the spillway.

A diversion flume 12 feet wide and 8½ feet deep, is located on the north end of the dam with an 11-foot wooden drop-type headgate controlling the flow of water in the flume (fig. 4). The width of the intake above the headgate is 30 feet.

There are no screens or other fish-protective devices in the flume to prevent the passage of fish into it from the Little Sandy, including fish which have entered the Little Sandy from the unscreened Marmot diversion. The dam is not provided with a fish ladder. At the time when observations were made all of the water from the Little Sandy River, with the additional water from the Marmot diversion, was being diverted into the reservoir flume leaving a dry river bed directly below the dam. On March 20, 1940, the entire flow of the Little Sandy River, which was 118 c.f.s., registered at the gauging station three-eighths of a mile above the dam, combined with the flow of 582 c.f.s. from the Big Sandy River, was being carried by the flume, 3 miles in length, to the Bull Run power plant reservoir.

BULL RUN POWER PLANT

The Bull Run power plant, owned and operated by the Portland General Electric Company, is located on the left bank of the Bull Run River 1½ miles above its mouth. Two large penstocks deliver water to the plant from the storage reservoir created by the diversion of water from the Little Sandy and Sandy Rivers. The intake to the penstocks is located at the north end of the reservoir in deep water. There is a 320-foot head from the reservoir to the plant where the water is piped through 4 turbines, each of which has an output of 5,000 kilowatts. The wheels of the turbines are of the high speed, Francis type, which operate at 514 revolutions per minute.

It is probable that most of the downstream migrant fish, that have been diverted into the reservoir from the Little Sandy and Sandy Rivers are killed when they pass through the turbines at the plant.

BULL RUN DAM

The City of Portland Municipal Water Department operates a diversion dam on the Bull Run River 6 miles above its union with the Sandy River (fig. 5). This dam has a crest length of 165 feet and a height of 40 feet, with a spill of water 6 inches deep over the crest at the time of the survey. Three concrete headgates, each 6 feet wide, control the flow of water into the city water supply diversion flume (fig. 6). These headgates are protected by an iron-grill trash rack having a bar spacing of 3 inches. In addition, revolving link-belt trash screens with a mesh of 1/2 inch are installed in the intake. A by-pass 36 feet long, located 42 feet above the intake gates, returns excess water back into the Bull Run River. A monthly record of the water diverted into the city water supply flume is shown in table 1.

Table 1. Monthly diversion in city water supply flume and overflow at the Bull Run diversion dam, 1938.

Month	Cubic feet per second	
	Flume	Overflow
January	62.4	1,411.0
February	63.5	581.0
March	60.4	1,102.0
April	64.6	1,401.0
May	71.4	603.0
June	89.2	114.9
July	98.3	32.4
August	85.7	30.4
September	70.1	38.3
October	65.6	45.8
November	63.2	1,001.0
December	63.9	1,171.0

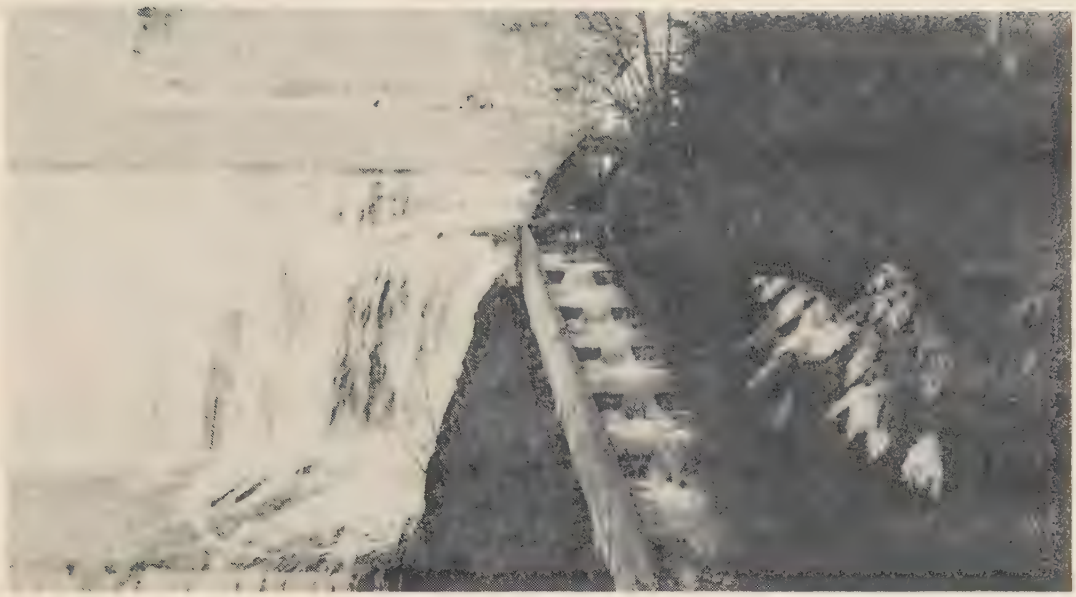

Figure 2. Fish ladder and south end of Marmot Dam on Sandy River.

Figure 3. Diversion dam of Portland General Electric Power Company on Little Sandy River

Old residents of the community report that before the diversion dam was built there was a large run of chinook and silver salmon and steelhead trout in the Bull Run River. When the dam was built it was not provided with a fish ladder and all fish since that time have been blocked off from the upper parts of this stream.

Five miles above the diversion dam the Portland Municipal Water Department maintains a high storage dam which is also an impassable barrier to migratory fish.

BIG SANDY CHANNEL DAM

There are two outlets of the Sandy River into the Columbia, the right or upstream outlet known as the Big Sandy Channel, and the left or downstream outlet known as the Little Sandy Channel. Formerly, the Big Sandy Channel carried the water of the Sandy River, although there were times especially during periods of high water when both channels carried the runoff. Loads of fine sand and silt have been deposited by the Sandy River at its mouth. These sediments are brought down river from the glaciers and, because of the slight gradient of the river of only 3 feet to the mile near its mouth, a large delta has been formed by their deposition. During periods of low water this stream area is composed of extremely shallow sand bars which obstruct the passage of salmon, trout, and smelt (Thaleichthys pacificus) from the Columbia River into the Sandy River. This condition has been the cause of considerable agitation for a number of years by local sportsmen for improvement of the entrance into the Sandy River for migratory fishes.

In 1938, a wooden dam was built across the Big Sandy Channel (fig. 7) at its upstream end to divert the river into the Little Sandy Channel. The dam is approximately 720 feet long and 10 feet high and is reinforced with rock. By the diversion of the Sandy River through the Little Sandy Channel, which has an unobstructed outlet to the Columbia, a passageway has been afforded for migratory fishes at all seasons of the year.

ARTIFICIAL PROPAGATION

In order to present a complete picture of the situation regarding migratory fish on the Sandy River, exclusive of the construction of dams, it appears advisable to refer to past activities which have influenced the welfare of these fish populations. A great deal of this information has to do with previous attempts at artificial propagation and a brief resume of these facts now follows.

The first attempt at artificial propagation on this stream of which we have any record was undertaken in 1896 when the U. S. Commission of Fish and Fisheries constructed a small hatchery near the confluence of Boulder Creek and the Salmon River. During that season 2,600,000 chinook salmon eggs were secured from 492 females. This hatchery was operated in 1897 and 1898 with the results shown in table 2, which indicates the eggs taken and their disposition during all hatchery operations on the Sandy River system.

Table 2. Number of eggs taken in the Sandy River System, and transfer of eggs between stations.

Year	Location of egg take	Number of eggs taken				Transfer of eggs				
		Chinook	Steel-head	Silver	Total	Chinook	Steel-head	Total	From	To
1896	Salmon R.	2,600,000	--	--	2,600,000	2,340,000	--	2,340,000	Salmon R.	Clackamas
1897	do	1,216,600	--	--	1,216,600	1,066,600	--	1,066,600	do	do
1898	do	745,200	22,000	--	767,200	43,000	3,500	46,500	do	Clackamas and Portland
1904	do	1,745,000	175,200	1,327,300	3,247,500	--	--	--	--	--
1905	do	1,230,000	1,066,300	300,000	2,596,300	--	--	--	--	--
1906	do	875,000	447,000	412,000	1,734,000	--	--	--	--	--
1909	do	681,336	--	76,500	757,836	501,336	--	501,336	do	Bonneville
1910	do	389,710	--	--	389,710	389,710	--	389,710	do	do
1912	do	2,426,550	--	--	2,426,550	2,067,800	--	2,067,800	do	Bonneville, Klaskanine and fairs
1913	Sandy R.	4,212,973	966,100	--	5,179,073	1,985,498	734,700	2,720,198	Sandy R.	Bonneville and Klaskanin
1914	do	--	449,500	--	449,500	--	307,470	307,470	do	Bonneville
1921	do	1,637,000	--	--	1,637,000	1,637,000	--	1,637,000	do	Clackamas
1922	do	461,900	634,000	--	1,095,900	--	634,000	634,000	do	do
1923	do	--	832,600	330,600	1,163,200	--	--	--	--	--
1924	do	--	--	--	1,823,918	--	75,000	75,000	Sandy R.	Clackamas
1925	do	2,595,820	--	--	2,595,820	--	--	--	--	--
1939	do	1,500,000	--	500,000	2,000,000	--	--	--	--	--

Figure 4. Flume intake of Portland General Electric Power Company at Little Sandy Dam

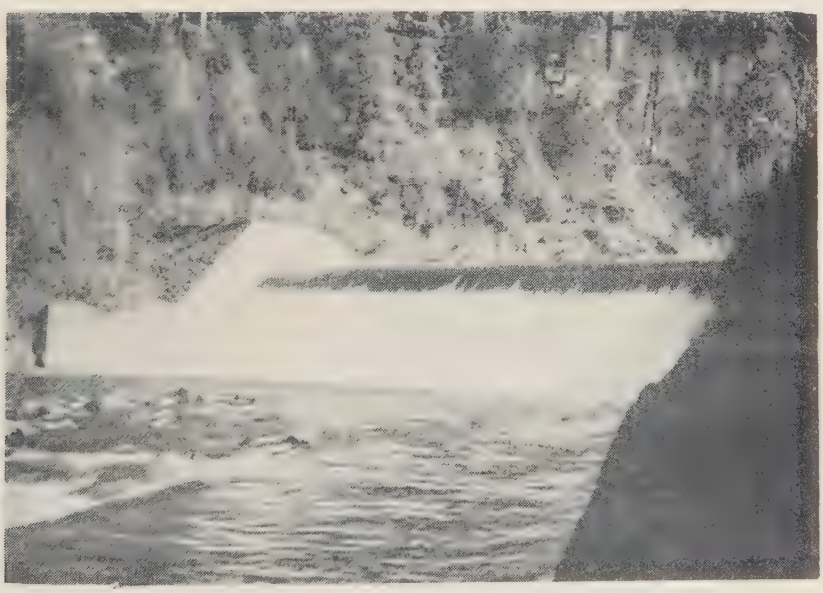

Figure 5. Diversion dam for Portland municipal water supply on Bull Run River

Figure 6. Flume intake for Portland municipal water supply at Bull Run diversion dam

Figure 7. Diversion dam in Big Sandy Channel

This station was turned over to the Oregon Fish Commission on June 15, 1898 and operated by that agency at irregular intervals as shown in table 3 until 1921. The hatchery was then operated by the U. S. Bureau of Fisheries up to and including 1924. The Oregon Fish Commission then operated hatcheries in 1925 and 1939.

Until 1913 egg taking and hatchery operations were carried on at the Salmon River location. However, during that year construction work on Marmot Dam made it difficult for fish to reach that stream and temporary facilities for taking and hatching eggswere set up below the dam. This procedure was followed in 1914. During 1915, 1916, 1917, 1919 and 1920 the Oregon Fish Commission reported expenditures on fish cultural work on the Sandy River but no records of the egg takes or liberations are available.

The information in table 2 was compiled from the following sources:

United States Commission of Fish & Fisheries, Commissioners' Reports, 1896-1897.

Annual Reports of the Department of Fisheries of the State of Oregon, 1907.

Annual Reports of the Master Fish Warden of the State of Oregon, 1909-1910, 1913, 1914.

Biennial Report of the Department of Fisheries of the State of Oregon, 1913.

Biennial Report of the Fish Commission, State of Oregon, 1919-1920, 1925-1926.

United States Bureau of Fisheries, Report of the Commissioner, 1922, 1923, 1924, 1925.

During the years 1896, 1897 and 1921-1924 the hatchery was operated by the former United States Bureau of Fisheries and during the years 1898, 1904 to 1906, 1910, 1912-1914, 1925 and 1939 by the State of Oregon. The 1,637,000 chinook salmon eggs taken in 1921 were shipped as eyed eggs to Clackamas. There is no record of the species represented in the total of 1,823,918 eggs collected in 1924.

In 1921 eggs were taken below Marmot Dam and the hatchery was operated by the United States Bureau of Fisheries. A hatchery building was then built by that agency on the Sandy River. In 1925, it was decided to close the station because of the unfavorable conditions caused by the diversion of much of the stream flow at Marmot Dam.

For the next 11 years the records available indicate that there was no hatchery activity on the Sandy River. In 1933, 1934, 1935 and 1936 an unknown number of salmon fry were taken from the Oregon Fish Commission hatchery at Bonneville and planted in the Sandy, Bull Run and Salmon Rivers.

At the present time the State Fish Commission of Oregon operates a new hatchery on the site of the former station at Marmot Dam which has been in operation for the past two years. In 1939, 1,500,000 spring chinook and 500,000 silver salmon eggs were taken. These were reared at the hatchery for release in the Sandy River. The rack site is located approximately one half mile above the dam and spawners are held and the eggs taken at that point. This spring a trap was placed in the fish ladder at Marmot Dam to capture the steelhead trout run. The seasonal diversion of the entire river flow from the 12 miles of channel below the hatchery remains a threat to its successful operation. In addition, the present water supply for the hatchery is unsatisfactory. The intake is on the power company's ditch and there is no provision for removing the heavy suspension of glacial silt and sand common to the Sandy River. An additional water supply is needed also to lower the high water temperatures prevalent through the summer months.

By reference to table 2 it can be seen that 1909 and 1910 provided small takes of eggs. This was believed due to a flood in 1904 which blocked the original channel of the Sandy River, with sand and debris where it entered the Columbia River, forcing the formation of another channel in an upstream direction. Partially successful attempts were made to reopen the old channel in 1911. The increased run of 1912 was believed due to these operations.

During the early years of artificial propagation on the Sandy River many eggs were transferred from that river to other stations. That policy of removing a large part of the offspring of the Sandy River chinook salmon and steelhead trout to other streams must have contributed materially to the decline of the runs entering the Sandy River.

SMELT

In addition to the salmonoid fishes, the Sandy River has in the past supported a smelt run of commerical importance. In past years this run has been depleted to the point where its occurrence is unpredictable. After 3 or 4 years during which no smelt were reported a large run entered the Sandy River early in March 1940 and continued to run for 11 days. Smelt are reported to confine their spawning activities to the lower 5 miles of the river. This section is characterized, especially near the mouth, by moderate riffles and an abundance of glacial silt and sand.

CHARACTER OF STREAM

The information relating to stream conditions which was obtained in the course of this survey has been summarized by plus and minus symbols, as shown in fig. 1 and table 3. These symbols indicate the probable value of these stream sections as fish spawning and producing areas.

The lower 2 miles of the Sandy River flows through farm and pasture lands bordering the Columbia River. The gradient is slight and the bottom

nearly 100 percent sand and silt. The gradient gradually increases for the next 14 miles and this section contains the most extensive spawning areas in the river. These areas are used chiefly by the fall run of chinook and silvers. High bluffs and hills restrict the river to a narrow valley densely wooded with fir, maple, cedar, and alder. The rolling hill crests and plateaus are extensively farmed.

Above the Bull Run River confluence the gradient is moderate to steep. Spawning areas in the 12-mile section to Marmot Dam are restricted by sand, boulders, and bedrock to small scattered "pockets". The surrounding hills are higher and more heavily timbered. Bedrock box canyons are common.

Between Marmot Dam and the Zigzag River confluence, a distance of 13 miles, the valley is from one-fourth to one half mile wide, stream banks are lower, and there are no canyons. The gradient is from 40 to 60 feet per mile. Here the river bottom is preponderantly large rubble and boulders with an admixture of silt and sand. Wide flood washes are frequent and spawning areas are small and scattered.

Upper Sandy and Zigzag Rivers.--Above the Zigzag confluence both the Sandy and Zigzag rivers rapidly increase in gradient as the slopes of Mt. Hood become more precipitous. Boulders, large rubble, and sand again predominate but there are small areas of good spawning gravel.

Salmon River.--The Salmon River is approximately 32 miles long and enters the Sandy 5 miles below the Zigzag confluence. While it heads in a glacier on Mt. Hood a greater part of the river flow is derived from springs. Consequently this tributary is less affected by silt and sand than the Zigzag or Sandy Rivers. Good spawning areas are common in at least the lower 7 miles of the river and in some places are extensive. This tributary is reported to have supported the largest steelhead trout, spring chinook, and silver salmon runs in the Sandy River system.

Bull Run River.--For many years the watershed of the Bull Run River has been set aside as a water supply for the City of Portland. An intake dam is located 6 miles above the confluence with the Sandy River and the salmon migration is confined to the river section below this structure. As this section of river is rough and the bottom is composed largely of bedrock and boulders, spawning areas are restricted to small, scattered "pockets". A few silver salmon and steelhead trout are observed every year below the dam. The surrounding hills are high and are densely forested.

Little Sandy River.--The Little Sandy River enters the Bull Run River approximately 3 miles above the confluence of the Bull Run River with the main Sandy River. It occupies a steep, densely wooded box canyon, and from the mouth to an impassable diversion dam 1½ miles above there are few patches of potential spawning rubble. It is only during brief freshet periods that water flows through the channel of this tributary. All normal flows are diverted to the Bull Run power house, together with the 500 to 600 c.f.s. diverted from the Sandy River at Marmot Dam. The Little Sandy River was flowing less than 5 c.f.s. at its confluence with the Bull Run River on March 20, 1940, and all of this water was derived from flume leakage.

Table 3. Tabulation of estimated value for salmon spawning in each mile of the Sandy River to Marmot Dam and sample areas above, 1940

Distance	Square yards of bottom	Percentage spawning rubble	Square yards spawning rubble (Nearest 100)	Probable Value	Location Point
1 mile	52,800	-	-	-/-	
2 miles	176,000	10.0	17,600	-	
3 "	161,910	38.3	62,000	+	
4 "	165,440	53.5	88,500	++	
5 "	158,430	29.9	47,400	-	
6 "	119,640	54.2	64,800	++	
7 "	(1)	(1)	(1)		
8 "	130,160	55.8	72,600	++	
9 "	137,200	54.3	74,500	++	
10 "	178,000	40.6	72,300	+	
11 "	158,000	39.0	61,600	+	
12 "	145,000	51.6	74,800	++	
13 "	129,000	49.5	63,900	++	
14 "	160,000	62.2	99,500	++	
15 "	102,000	31.6	32,200	+	
15¾ "	63,000	28.3	17,800	-	Confluence Bull Run River
17 "	69,400	22.6	15,700	-	
18 "	86,400	26.0	22,500	-	
19 "	111,900	40.7	45,500	+	
20 "	121,000	30.5	36,900	-	
21 "	63,200	22.1	14,000	-	
22 "	58,200	16.3	9,500	-	
23 "	(1)	(1)	(1)		
24 "	(1)	(1)	(1)		
25 "	(1)	(1)	(1)		
26 "	(1)	(1)	(1)		
27 "	64,300	8.8	5,700	-/-	
27¼ "	7,600	5.5	400	-/-	Marmot Dam
27¾ "	74,700	-		-/-	
28¼ "	62,000	40.0	24,800	+	
1,000 yards	33,000	10.0	3,300	-/-	Near Wild Cat Creek
700 "	22,500	26.7	6,000	-	Near Sleepy Holl
200 "	3,000	10.0	300	-	Near confluence Clear Creek

1/ Impassable for survey.

Table 3. Continued

Distance	Square yards of bottom	Percentage spawning rubble	Square yards spawning rubble (Nearest 100)	Probable Value	Location Point
			Bull Run River		
1 mile	72,800	23.4	17,000	-	
2 miles	42,800	4.4	1,900	-/-	
3 "	45,750	7.7	3,500	-	
4 "	42,200	0.4	200	-/-	
5 "	47,500	1.0	500	-/-	
6 "	45,750	2.4	1,100	-	Portland Water Intake
			Zigzag River		
300 yards	6,700	58.6	3,900	+	Near Mouth
400 "	6,600	30.0	2,000	-/-	Below Still Creek
			Salmon River		
600 yards	21,100	33.1	7,000	+	Near Mouth
400 "	11,200	74.3	8,300	++	Near Welches

MINOR TRIBUTARIES

Gordon Creek is the largest of the minor tributaries and enters the Sandy River about 11 miles above its mouth. It is reported to be a fairly good trout stream. The gradient is steep and the marginal vegetation dense. It maintains a fair flow through the summer months when other tributaries of the lower Sandy River are nearly dry. The flow was estimated at between 60 to 80 c.f.s. on March 18, 1940.

Trapper and Trout Creeks enter the Sandy River near Gordon Creek and at the time of the survey were estimated at 10 to 12 c.f.s. and 15 to 20 c.f.s. respectively. These tributaries reach a very low water stage in the summer but may provide some spawning areas for the fall sea-run cutthroat or "harvest" trout.

Cedar and Badger Creeks enter the Sandy River in the section below Marmot Dam which normally becomes dry during the summer months because of the Marmot Dam diversion. Of the two, Cedar Creek is the larger with an estimated flow of from 10 to 12 c.f.s. on March 20, 1940. It maintains a small flow through the summer and is of little or no importance as a salmon stream.

Minor tributaries above Marmot Dam used to some extent by spawning salmon and steelhead include Clear Creek on the Sandy River, Steel Creek on the Zigzag River and the South Fork of the Salmon River. As these tributaries are short and have steep gradients, it is probable that fish are not able to ascend far above their mouths.

In general the Sandy River and tributaries provide adequate pools and marginal shelter throughout.

VOLUME OF FLOW

In 1938 the maximum flow of the Sandy River below the Bull Run confluence was 21,500 c.f.s., minimum 302 c.f.s.; maximum above Marmot diversion 10,600 c.f.s., minimum 273 c.f.s. The maximum flow of the Salmon River above Boulder Creek was 4,020 c.f.s., minimum 73 c.f.s. Maximum of the Bull Run River above the Portland Water intake was 7,450 c.f.s. with a minimum of 103 c.f.s. (controlled by storage). In the Little Sandy River the maximum flow was 1,490 c.f.s., minimum 10 c.f.s. In all instances the minimum flow occurred in September.

GENERAL DISCUSSION

The general situation presented by the results of this survey can be stated rather briefly and definitely. At the present time, the situation on the river system as a whole is not encouraging. The Bull Run River is obstructed 6 miles from its mouth by an impassable dam. The stream above this dam is used as a source of municipal water supply by the City of Portland and salmon probably would not be allowed to use the stream for spawning purposes under any conditions because of their habit of dying

after spawning, which might be considered a source of pollution. The lower 6 miles of the Bull Run River, which is open to fish, contains very little spawning area, so this stream must be considered to be of little if any actual or potential value to migratory fish.

An impassable dam about 2 miles up the Little Sandy River from its confluence with the Bull Run River usually diverts the entire flow of the Little Sandy River through the power plant of the Portland General Electric Company. Therefore, it is of no use to migratory fish at the present time.

The main Sandy River has a section, about 16 miles in length, from its mouth to the confluence of the Bull Run River, which is unobstructed, free of diversions and contains a considerable amount of good spawning area. This section is suitable for fall-run chinook or silver salmon. Probably some steelhead trout also spawn in this section, although most of that species apparently go on into the upper part of the stream. There is but little spawning gravel between the mouth of the Bull Run River and Marmot Dam, a distance of about 11 miles. Also, during late summer and early fall there is often little if any water in this section of the river, due to the Marmot Dam diversion, which takes the entire river flow at times when the river is extremely low. This water returns to the Sandy River through the Bull Run power house and the Bull Run River. This condition prevents the migration of fall-run chinook salmon from going past the mouth of the Bull Run River, since they are present at the time when low water may be expected. Some silver salmon and steelhead trout may also appear at that time, although the main run of these species usually occurs when sufficient water is present to get them to Marmot Dam.

Above Marmot Dam there is about 18 miles of the Sandy River which is not of much value as spawning area. The Zigzag and Salmon Rivers enter the main stream in this section and both contain suitable spawning habitats for salmon. The Salmon River was apparently at one time the chief producer of steelheads and spring chinooks in the entire system.

This section above Marmot Dam has its value for producing migratory fish greatly impaired by the diversion at that structure. The lack of water between Marmot Dam and Bull Run River, which often occurs in late summer and early fall when this diversion takes the entire flow of the river, makes this upper part of the stream usually inaccessible to fall-run chinook salmon. The diversion, which is unscreened, also presents a major hazard to downstream migrant salmon and steelheads, since any such fish entering this diversion must pass through the turbines of the Bull Run power house, where they would probably be killed, before returning again to the stream. Since this diversion takes a considerable proportion of the river flow, even in the spring when the major downstream migration is to be expected, it must cause a considerable loss of young fish hatched in the upper reaches.

Under present conditions the logical program for the management of this stream for the purpose of salmon production, appears to be as follows: The section below the mouth of the Bull Run River should be stocked with fall-run chinooks in order to build up the run now present. It is suggested that

the eggs producing these fish be incubated in temporary troughs, or at least the young fish held for a little time in temporary ponds on the Lower Sandy River before liberation, in order to insure more satisfactorily their return as adults to that stream. Also, the Oregon Fish Commission should be encouraged to maintain their hatchery at Marmot Dam, taking all adult fish which arrive at that point for spawning purposes. The offspring of these fish should be held until migration time and liberated below the dam, when adequate water is present in that portion of the stream. This procedure would eliminate losses occasioned by downstream migrants entering the unscreened Marmot diversion.

A further step would be to establish a hatchery on the Bull Run River below the City of Portland diversion dam. This hatchery should be devoted chiefly to the propagation of fall-run chinook salmon and the restocking of the Lower Sandy River. This general location has several advantages over the Lower Sandy itself. Racks could be placed and mature fish taken without interfering with salmon which might otherwise spawn naturally in the Lower Sandy, and fish which come into the Lower Bull Run now and stop at either the power house tailrace or the diversion dam where they may die before spawning, or at the best spawn inefficiently, would be salvaged. Also there apparently is no good hatchery water supply on the Lower Sandy. On the Bull Run water could probably be secured from either the river itself or the Portland water supply diversion.

A third alternative, which would make possible complete utilization of the Sandy River system, except for the Bull Run, which must be considered as permanently eliminated, would be to screen the Marmot diversion and make arrangements for the maintenance of enough flow in the Sandy River between Marmot Dam and the mouth of the Bull Run River at all times to permit the passage of fish both up and downstream. The entrance to the Marmot Dam fish ladder should also be improved. This plan would not be easy to accomplish. The screening of the Marmot diversion would probably be a rather expensive undertaking and it is possible that the Portland General Electric Company could not provide water for fish below the Marmot Dam and still operate their Bull Run power house efficiently.

Also, if the upper reaches of the Sandy River and the Zigzag and Salmon rivers were made available to migratory fish, the plan of operation of the Oregon Fish Commission would have to be changed. Since they should not intercept the run at Marmot if good spawning and rearing conditions are available above there, it would be necessary to discontinue operations at their present site. It is possible that they might be able to move their hatchery to the Salmon River, where hatcheries have been operated before, and assist in the restocking of the upper streams with spring chinooks and steelhead trout.

Sport fishing in this river system consists primarily of angling for steelhead and sea-run cutthroat trout and the dipnetting of smelt in the lower portion of the Sandy. Fishing for resident cutthroat and rainbow trout is also carried on throughout nearly the entire river system, except in the

Bull Run above the Portland diversion dam. All of that portion of the watershed is closed to the public. Because of its close proximity to Portland, Oreg., the Sandy River is of considerable importance for sport fishing and recreational purposes. Any activities directed toward the improvement of conditions for salmon would, of course, have the same beneficial effect upon the steelhead trout runs, it being assumed that any hatcheries established would propagate steelheads as well as salmon.

It should be noted that the unscreened Marmot diversion is not as destructive to the game fish as it is to the salmon. Downstream migrant salmon must go through the diversion, the reservoir, and the power house in order to get back into the river and ultimately reach the ocean. However, many of the trout apparently stop in the reservoir before going through the power plant, so that this reservoir is one of the favorite fishing spots of the entire river system. Even steelhead trout, both immature downstream migrants and spawned out adults, are caught by anglers in this reservoir before they enter the power plant.

The dam constructed by the Oregon Game Commission at the mouth of the Sandy River which diverts the flow through the Little Sandy Channel, thus providing much improved conditions for the entrance of salmon, migratory trout and smelt into the Sandy River from the Columbia River, should accomplish good results. Before this improvement was made, it was difficult for these fish to enter the Sandy River, particularly at low water seasons. Therefore, the proposed expenditure of federal funds for the purpose of making this structure and channel permanent appears to be warranted. The planting of fall-run chinooks in the lower Sandy should be attempted even under present conditions and if a hatchery could be placed on the lower Bull Run River, conditions affecting migratory fish in the Sandy River should be much improved. The suggestion of the lower Bull Run River as a hatchery site should, of course, be checked by the Division of Fish Culture and others.

It is felt that before any definite recommendations are made as to utilizing the entire upper reaches for migratory fish by screening the Marmot diversion and providing a greater flow below Marmot Dam at low water seasons, a careful study should be made of the feasibility of the plan with particular attention to the costs of such activities and the extent of interference with the operations of the Portland General Electric Company. If the middle Columbia River is ever developed intensively for navigation and power, so that it is not practical for salmon to reach the upper spawning tributaries of the river, such a plan for intensive development of the Sandy would be much more attractive than it is now, because under such conditions it would be necessary to develop all large tributaries below Bonneville Dam to the fullest extent.

CONCLUSIONS

1. The main Sandy River from its mouth to the confluence of the Bull Run River is suitable for fall-run chinook salmon, silver salmon and steelhead trout.

2. This stream from the entrance of the Bull Run River to Marmot is of little value for spawning or rearing because of the extremely small flow present during late summer and early fall. This condition is caused by the diversion at the Marmot Dam taking out almost the entire low water flow of the river.

3. The Sandy River above Marmot Dam is made hazardous to migratory fish at the present time by the unscreened Marmot diversion.

4. The Upper Sandy and Zigzag Rivers offer favorable spawning areas for spring chinook salmon and steelhead trout; both species were abundant in those streams during former years. The unscreened Marmot diversion makes it inadvisable to permit these species to go into this area at this time.

5. An impassable dam, 6 miles above its mouth, blocks the Bull Run River to fish beyond that point. The 6 miles open to fish is not good spawning area and the remainder of the stream will never be open to salmon since it is used as the source of water supply for the City of Portland, Oreg.

6. The Little Sandy River is blocked by an impassable dam 2 miles above its confluence with the Bull Run River. Its entire flow is taken out at that point during low water seasons.

7. The small tributaries below Marmot Dam are not significant as spawning areas and do not offer any good hatchery sites.

8. The Sandy River system has significant populations of steelhead, sea-run cutthroat and resident trout and has distinct recreational value. Its close proximity to Portland, Oreg., is a factor which considerably increases its value for recreational purposes.

RECOMMENDATIONS

1. The Little Sandy Channel should be kept open and the flow of the Sandy River continue to be diverted into that channel in order to insure favorable conditions for the entrance of fish into the Sandy River from the Columbia River. Therefore, whatever construction work is necessary should be done to insure the permanency of the diversion dam at the mouth of the Sandy River and an adequate flow down the Little Sandy Channel.

2. The number of fall chinook salmon spawning in the Sandy River between its mouth and its confluence with the Bull Run River should be increased by planting the young of those fish in that section of the stream.

3. These fish should be obtained from eggs hatched on the Sandy River system and the young fish should be reared there before liberation.

4. This should be accomplished by either setting up temporary hatchery facilities or the establishment of a small permanent hatchery.

5. The lower Bull Run River, below the Portland diversion dam, is apparently the best site for such a hatchery.

6. If full development of the river should be undertaken, the Marmot diversion of the Portland General Electric Company must be screened and sufficient flow maintained in the Sandy River between that point and the confluence of the Bull Run to provide for free passage of both mature adults and downstream migrants.

7. This plan should be carefully examined as to practicability and probable cost before being seriously considered.

8. The Oregon Fish Commission should be encouraged to continue operation of their hatchery at Marmot and liberate the young fish below the dam since this saves the loss of young fish in the Marmot diversion, which would occur if natural spawning were allowed above Marmot Dam.

9. Any plan of improvement of the salmon runs by hatchery operations should include propagation of steelhead trout and other sport fishes.